WIRELESS NETWORK SELF-ADAPTIVE LOAD BALANCER

Background of the Invention

The present invention includes embodiments directed to the field of wireless local

5   area networks (WLANs) comprised of a number of wireless access points (APs). In a

typical WLAN, it is common to use APs having more than one radio occupying different

service frequency bands and/or different channels within a band. In a WLAN, an AP can

have an overlapping coverage area with one or more other APs. When coverage areas

overlap, any single client entering the network has a discrete set of (different) probabilities

10   of entering via more than one AP radio. If there is a large incidence of overlapped coverage

within a WLAN system, the load of wireless traffic can become skewed so that a large

portion of the load is handled by only a portion of AP radios, while other AP radios are

neglected. This leaves the network in a sub-optimal operational state.

This scenario is very likely in multichannel APs, where so-called "sectorized

15   antennas" are in fact overlapping in a large portion of their coverage areas. When the load is

imbalanced in this fashion, packet collisions increase and thus throughput is compromised,

since the WLAN has unused capacity. Since network utilization is improperly distributed,

other problems typically associated with an overcrowded network are observed, such as

reduced quality of service and so forth.

20   It is therefore desirable to obtain a load balance of client wireless traffic between AP

radios in order to maximize throughput and minimize latency for the wireless subsystem.

Load-balancing algorithms have previously been devised to kick some clients off a

particular AP radio to allow it to associate with another radio and thereby achieve a more balanced distribution of wireless traffic. Directed re-association has also been used, in which a particular client is specifically instructed to contact a particular AP for re-association. Traditional load balancing algorithms typically use heuristics and parameters

5   tailored to specific operational scenarios. Hence, significant network testing for a particular scenario is required to establish the operational guidelines required by such approaches. Classic approaches include the threshold algorithm, central algorithm, Centrex algorithm, and hybrids thereof, as are understood in the art. All of these approaches suffer in performance when the system characteristics fluctuate significantly (as they do in a

10   practical WLAN system). Thus, no previous-type approaches have been able to provide a satisfactory solution to the problems of obtaining a load balance.

<div align="center">Summary of the Invention</div>

      The difficulties and drawbacks associated with previous-type systems are overcome

15   by the wireless local area network of the present invention which includes a plurality of wireless access points each having a predetermined coverage area, and a plurality of wireless clients for establishing a wireless link with at least one wireless access point. Some or all of the wireless clients are within the respective coverage areas of at least a portion of wireless access points. A load balancer is provided for balancing distribution of

20   wireless clients among wireless access points. The load balancer includes a tracking implementation for tracking at least one telemetry parameter of each wireless client's wireless link with each respective wireless access point. A goal implementation is included

for comparing the at least one telemetry parameter against at least one predetermined goal to obtain a fitness measure. A control implementation is also provided for varying the operation of at least one of the respective wireless access points and wireless clients in response to the fitness measure, so as to balance the distribution of wireless clients among

5 the respective wireless access points.

As will be realized, the invention is capable of other and different embodiments and its several details are capable of modifications in various respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative and not restrictive.

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Brief Description of the Drawings

Fig. 1 shows a WLAN including a load balancer in accordance with the present invention.

Fig. 2 is a detail view of the load balancer and its operation in accordance with the

15 present invention.

Detailed Description of Embodiments

The embodiments of the present invention as described herein are contemplated as providing a load balancing method and apparatus that is adaptive to changing and

20 unanticipated variations in a WLAN. To that end, a wireless network self-adaptive load balancer is disclosed that seeks the best available load balance solution for providing a balanced distribution of a plurality of wireless clients communicating between a plurality of

wireless access points, in a scenario where the available network capacity is higher than the demand for a given topology of APs and clients.

The present self-adaptive load balancer preferably includes an architecture as shown in Fig. 1. In a WLAN network 10, a plurality of clients is under the purview of one or more APs 14, each containing one or more radios for various wireless channels. The network 10 is preferably fully connectable. The APs 14 are interconnected by a local area network (LAN) for enabling wireless clients 12 to exchange data frames with various network devices and other wireless clients 12 associated with other APs 14. A load balancer 20 may be implemented as software or in a discrete unit located either in a centralized component on the LAN or within one of the APs 14 (especially if multi-channel). The load balancer 20 may also be functionally distributed among some or all of the APs 14 throughout the network.

The load balancer 20 includes a "fitness measure" subsystem 22 including a tracking implementation for tracking one or more telemetry parameters characteristic of the wireless links of each wireless client. These telemetry parameters can include packet error rate, signal strength, channel, rate, processor performance, and any appropriate additional signal metric or data transfer property of the wireless link.

A goal implementation is included with the fitness measure subsystem 22 for comparing the telemetry parameter(s) against a number of respective goals for optimizing load distribution and data throughput for each wireless link. One goal is that equal load should be achieved on each AP 14 or radio. Another goal is that maximum received signal strength should be achieved for each client-to-AP wireless link. Also, maximum link

quality is desired, in which it is desired to minimize "multipath", signal interference, packet

loss, provide maximum signal quality at a maximum data transfer rate, and to provide a

low packet error rate. Another goal is to provide balanced AP digital processing

performance, including adequate CPU processing cycles, adequate memory capacity, and

5   adequate uplink network capacity. Since a number of different type APs 14 may be

operating in a WLAN having widely different environmental conditions, a balanced

distribution must take these factors into account, in view of real-time-varying changes in

network traffic, environment and topography. The goal implementation compares the

measured telemetry parameters against these desired goals to obtain a "fitness measure" for

10   the load balancer.

The load balancer 20 further includes a self-adaptive subsystem 24 including a

control implementation that uses various control mechanisms to vary the operation of one

or many of the APs 14 and clients 12, so as to balance the distribution of wireless clients 12

among the APs 14. The control mechanisms of the control implementation include a

15   WLAN admission control of clients, so as to defer a client from associating with an AP 14

at a given time, or to force a client 12 to change frequency, and to assign or steer AP

antenna coverage patterns and/or polarization. Other control mechanisms include varying

the signal power of the clients and/or APs, changing the data rate, coding, and modulation

of the signal, and varying the packet length and other controllable protocol characteristics.

20   In addition, the load balancer contains an implementation whereby it can modify the fitness

measure definition, so as to achieve any desired or practical load distribution or to adapt to

variations in network demand or other changing performance factors.

The present self-adaptive subsystem 24 applies the fitness measure to the control

mechanisms to build a database of control vectors, sorting them by the value of their

corresponding fitness. An adaptation algorithm proceeds in a measured fashion so that large

performance swings are avoided. The load balance thereby progresses toward an optimal

5   state over the course of repeated iterations. A secondary control loop provides feedback

from the adaptive subsystem to accommodate modifications in the fitness measure. In

particular, insensitive telemetry measures may be de-weighted while sensitive parameters

can be heavily weighted in order to provide well-behaved control values to the APs.

Any number of self-adaptive engine algorithms may be used within the load

10   balancer. For example, gradient search, neural network, simulated annealing, genetic

algorithm, or other such algorithms may be employed. The selection may be made for a

particular WLAN based upon the ability of the algorithm to adapt quickly to the dynamic

changes experienced in the specific WLAN environment. Each of these techniques is robust

with respect to obviating the need for tailoring parameters to a specific operational scenario.

15   The invention is thus highly beneficial in that no a-priori operational criteria need be known

in order to assign the fitness measures and thereby the control functions. Additionally, the

choice should be such that local performance minima do not become points of static, non-

optimum operation. From this standpoint, the preferred embodiment would include a

genetic algorithm or hybrid thereof

20   The present wireless network self-adaptive load balancer 20 is superior to classic

load balancing approaches in its ability to deal with rapidly varying environments and

changes in topology. It possesses the characteristic of discovering and ranking the control

parameters of greatest benefit and/or sensitivity, tailoring its movement of those controls in order to minimize adverse impact on the network throughput. The class of algorithms used to implement this load balancer is robust and simple, able to be hosted either within an AP processor or on a network host. The present invention thus has particular applicability for

5   wireless products that employ multichannel radios in single access points as well as multiple simultaneous channels derived from access points using adaptive array antenna systems. Additionally, the present approach may be applied to any wireless local area network management system that controls multiple single radio access points.

As described hereinabove, the present invention solves many problems associated

10   with previous type systems. However, it will be appreciated that various changes in the details, materials and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention may be made by those skilled in the area within the principle and scope of the invention will be expressed in the appended claims.

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